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Grade 1 to 6 Thai Students' Existing Ideas about Energy

CHOKCHAI YUENYONG, (ychok@kku.ac.th), *Khon Kaen University Thailand*
JIRAKARN YUENYONG, *Khon Kaen University Demonstration School, Thailand*

ABSTRACT *This study explored 30 Grade 1 to 6 (6 – 12 years old) Thai students' existing ideas about energy. The study employed the Interview about Event (IAE) approach. During IAE, the cards of an event or things were showed to students in order to probe their views of energy concepts. Findings indicated that young students held various alternative conceptions about energy that could be categorized into five different groups relating to electric energy, potential energy, mechanical energy and forces, heat energy, and fuel. Most of Grade 1 to 3 students considered energy as mainly mechanical energy and forces, or electric energy, while the majority of Grade 4 to 6 students clarified their ideas about energy by referring to potential and electric energy. The paper discusses the findings and their implications for teaching and learning with reference to a teaching unit that was developed and evaluated using Thai primary school students.*

KEY WORDS: *Energy, transformations of energy, teaching and learning.*

Introduction

According to Thailand educational reform, the Ministry of Education launched the National Education Act in 1999 (ONEC, 2000). The Thai education system consists of 4 levels that are pre-school, primary, secondary, and higher education. Basic education consists of twelve years core curriculum with 4 different levels that are the lower primary education (Grades 1 – 3 or 7 - 9 years), upper primary education (Grades 4 – 6 or 10 – 12 years, lower secondary education (Grades 7 – 9 or 13 – 15 years), and upper secondary education (Grades 7 – 12 or 16 -18 years). All students in each grade level are expected to achieve the same learning goals, while the content of teaching is similar, but more information is progressively offered and more complex analyses are used. The body knowledge addresses skills or learning processes, values or virtues, morality, and right behavior (MOE, 2002). The science content covers eight areas that are: (1) Living things and their survival, (2) Life and environment, (3) Matter and its properties, (4) Force and motion, (5) Energy, (6) Earth science, (7) Space and astronomy, and (8) Nature of science and technology. Each science content area should be taught in every grade level (IPST, 2002) by progressively increasing the depth of knowledge and understanding.

Based on the new wave of Thailand educational reform, teaching and learning science is becoming increasingly important. Students should study science starting from the 1st Grade level (IPST, 2002). This is a challenge for teachers who should learn how to teach science for young children. Especially, the teaching of abstract concepts, such as energy. As a totally abstract concept, energy can be only under-

stood through forms of energy, energy transformations, energy transfer and degradation, and the law of energy conservation (Duit, 1984). Forms of energy are generated from energy sources that can generate energy in various forms. Physicists classify energy into several different categories including kinetic, gravitational potential, elastic potential, chemical, thermal, electric, radiant, and nuclear energy (IPST, 2002). Energy transformations involve the concept that energy can be manifested in several forms, and it can be converted from one form to another (Duit, 1984). The law of energy conservation is the concept that the total energy of an isolated system always remains the same, regardless of any processes occurring within the system. When energy is transferred from one system to another, or when energy is transformed from one form to another, the amount of energy does not change (Duit, 1984; Hobson, 1982). Energy degradation is the simple concept of entropy (Duit & Haeussler, 1994). Using the concepts of thermal energy and temperature, entropy is given the meaning of the concept of disorganization. The disorganization in isolated systems can easily become more disorganized, but those systems can become more organized only with outside assistance (Hobson, 1982). As with the simple concept of entropy, the concept of the degradation of energy involves the processes taking place in closed systems where the amount of energy does not change, but the usefulness of the energy inevitably is reduced, and is hard to reverse the process and make energy more useful (Duit & Haeussler, 1994).

However, student's existing ideas about energy were found to be different from the scientific world-view. Many western research studies indicated that conceptions both before and after teaching reflect the use of energy in students' life-world domain. This is especially so when an energy concept is in use that differs from the science energy concept (Duit & Haeussler, 1994). Studies in the English language context (Watts & Gilbert, 1983; Solomon, 1983; Brook & Diver, 1984; Bliss & Ogborn, 1985; Gair & Stancliffe, 1988) have generally resulted in a considerable percentage of human-centered ideas of energy, and of associations with food. Findings from Germany (Duit, 1981) also indicated that the framework of human-centered energy is very infrequent. Findings from Israel (Trumper, 1990) and the Netherlands (Lijnse, 1990) have commonly shown a high percentage of the idea of energy in terms of fuel. Similarly, findings from Thailand (Sengsook, 1997) have shown a high percentage of Grade 7 to–12 students' ideas of energy in terms of fuel.

Teaching and learning about energy for primary students in Thailand usually emphasizes forms and sources of energy. Lower primary students have to study electric energy from battery and electrical devices, sources of energy, and energy saving. Upper primary students are required to study light, sound, and electric energy, and its sources. The concept of energy transformation is also taught to upper primary students (IPST, 2002). From a constructivist perspective, the teacher should investigate students' prior knowledge and develop ways that incorporate these viewpoints within teaching (Trumper, 1990; Duit & Haeussler, 1994).

Nevertheless, when attempting to teach energy in primary schools, there is lack of any attempt to investigate primary students' existing ideas about energy. This study presents an attempt to identify primary school students' existing ideas about energy (e.g., forms and sources of energy). The findings will be then examined in terms of how primary school teachers can use them to extend students' understandings about forms of energy, energy transformation and degradation, and the law of energy conservation.

Methodology

The present study was a naturalistic inquiry conducted within a constructivist paradigm. Students' existing ideas about energy were elicited by dialogue between researchers and participants (Johnson & Gott, 1996).

Participants

The sample of the study consisted of 36 students including 3 boys and 3 girls from each grade level, namely, Grades 1 to 6 from a school in a province of Thailand. The majority of students' parents were working either as teachers or officers in the university, and only few of them were employed in other businesses and government offices in the city of Khon Kaen.

Data collection

Data collection involved the identification of students' existing ideas about energy using semi-structured interviews, including the use of Interviews about Events (IAE) approach. Development of IAE focus cards was based on an eight step algorithm developed by Gilbert, Watts and Osborne (1985). All interviews were audio-taped and fully transcribed. The interview began with the researchers showing the participant a card of a sample or object, such as, a dish of fish, a boy running, a boy playing football, a battery, a factory, a power plant, a dam, and coal. The student was then asked whether the sample or the object in a card was somehow related to energy. In case of a positive answer, students were then asked to provide explanations that could elicit his or her understanding about energy, while the interviewer could further probe for clarifications and needed extensions of students' ideas, but without any attempt to modify their initial ideas.

Results

All interviews were audio taped and fully transcribed. Students' responses relating to each card were analyzed and then categorized as students' frameworks of energy. Each category was combined with students' dialogue to develop their frameworks. These ideas were then compared and contrasted using the percentages of the students' framework descriptions in each category. Students' explanation of cards could be categorized into five frameworks. These include electric energy, potential energy, mechanical energy and forces, heat energy, and fuel.

Students' Framework of Electric Energy

Students referred to the term of energy for explaining the card of a sample or an object. Interestingly, students' explanations from Grade 1 to 6 were based on the use of energy or ideas relating to transformations of energy in the samples or objects depicted by the cards. For example, cards of battery, factory, power plant, and dam were usually explained by stating that these use energy, and finally these forms of energy are transformed into electric energy. Most students stated that a dam is generating energy or that the dam is "changing" water energy into electric energy. Leo (Grade 1), for example, stated that dam is producing electric energy from water energy.

Interviewer: Do you know what the card is about?
Leo: Yes. It is about a dam.
Interviewer: Can you tell me how does it relate to energy?
Leo: Yes.
Interviewer: Please, tell me.
Leo: Because, it changes water energy into electric energy.

Using electric energy was also explained as a concept of energy transformation. Most students explained that electric energy was used or changed into light energy and energy for rotating machines. Kla (Grade 6), for example, stated that electric energy was used for rotating the machines in a factory to produce several goods.

Interviewer: Next card

Kla: Card of a factory, it has to use energy. The factory uses electric energy to produce several goods. Electric energy is used for rotating a machine in the factory. …

It was however evident that some students were familiar with only some forms of energy, such as electric energy. They strongly believed that some cards presented to them (e.g., a boy running, a boy playing football) did not relate to energy. Top (Grade 3), for example, thought that a boy playing football do not relate to energy, because there is not any electrical wire in that boy.

Interviewer: What is this, Top?

Top: A boy is playing football

Interviewer: Does the picture indicate something related to energy? Could you please explain?

Top: No… um… It did not relate to energy.

Interviewer: Do you have any reasons?

Top: The boy does not have any electrical wire connected with him. …

Kin (Grade 2) also stated that that a running boy does not relate to energy, because the does not have a battery.

Interviewer: What is about this card?

Kin: A boy is running

Interviewer: Whether it relates energy or not? Could you please explain?

Kin: No, it does not.

Interviewer: Why?

Kin: He is not inputted battery

Interviewer: Um, he is not… If it is robot, would it relate energy?

Kin: Yes, it would.

Students' Framework of Potential Energy

Cards of a boy running, a boy playing football, a dish of fish, a dam, and a gas station were usually explained in the framework of potential energy. Although students did not mention the term potential energy, their explanations concerned depository of energy in things and living things. Students explained that energy is deposited in food and fish, human, muscle of human, coal, or water in the dam. Their explanations seemed to indicate that they recognized the potential energy

that was deposited. Interestingly, Grade 1 to 6 students recognized the concept of chemical potential energy, even though they did not mention the term. Bow (Grade 2), for example, stated that fish had energy, because it can give people energy.

Interviewer: What about this card?

Bow: Food, ... fish

Interviewer: Does it relate to energy?

Bow: Yes, it does. It makes us stronger.

Interviewer: Anything else?

Bow: If we eat fish, it will give us energy.

The concept of gravitational potential energy was rarely recognized, but it has been increasingly mentioned in upper primary students. Yijung (Grade 5), for example, stated that the dam had water energy that could produce electric energy.

Interviewer: Next card?

Yijung: Dam, it relates energy. ...

Interviewer: What energy?

Yijung: Water energy, people use it to produce electric energy.

A number of students could not however recognize potential energy. Most of them thought that the fish, the dam, a boy running, a boy playing football, coal, and the gas station did not relate to energy. Top (Grade 3), for example, thought that fish did not relate to energy, but it related to energy only when people sailing a boat were out for fishing.

Interviewer: Next card

Top: Fish, but it does not relate to energy

Interviewer: Could you please give a reason? Why does it not relate to energy?

Top: I think that it relates to energy only when people use a boat and go for fishing.

It also seemed that students did not recognize the concept of potential energy, because they believed that energy relates to "moving" or mechanical energy. Moddaeng (Grade 5), for example, stated that coal did not relate to energy, because it did not or could not move.

Interviewer: The last card

Moddaeng: coal, I think that it does not relate to energy, because it does not move. If relates, it is burned. .....

Students' Framework of Mechanical Energy and Forces

Students explained the content of some cards by relating it to movement, forces, and working machines. We considered these explanations as indicating that the students held the concept of energy as it relates to mechanical energy and forces. Students usually explained that the cards of a boy running and a boy playing ball related to energy when the boy used "his force" for running or kicking the ball. The cards of coal, a battery and a gas station were also explained as agents that forced something to move and made a machine to function or work. Nut (Grade 6), for example, stated that the dry cell or battery can force a toy car to move.

Interviewer: Next card

Nut: Dry cell. It means that we put cathode and anode into a toy car. Dry cell, then, will force a toy car to move. …

Interviewer: Does it relate to energy?

Nut: Yes, it does. Dry cell can produce electricity.

Wut (Grade 3) also stated that a boy playing football related to energy, when the boy was kicking the ball.

Interviewer: Another card

Wut: Boy is playing football. I think that it relates to energy, because there is force from the boy.

Interviewer: Why? Could you explain more?

Wut: The boy can kick the ball into the sky. …

Interestingly, it seemed that some students expressed the concept of energy transformations when they were attempting to explain the content of the cards. Their explanations focused on transforming different forms of energy into kinetic and electric energy, and so on. For examples, Nut (Grade 6) tried to explain the card of a battery by making reference to the transformation of electric energy into kinetic energy.

Students' Framework of Heat Energy

Some students also recognized heat energy when they attempted to explain the cards of coal, a battery, and a power plant. Heat was mentioned in the sense that heat is released when using these sources of energy. Converting forms of energy into heat was also mentioned during their explanation. Bell (Grade 6), for example, stated that electricity was generated by heat, when she had to explain energy in the card of the power plant.

Interviewer: What about this card?
Bell: It is a power plant. It provides us electricity. The electricity is generated by heat.
Interviewer: So, does it relate to energy?
Bell. Yes, because heat generates electric energy.

Students' Framework of Fuel

Students' explanations related energy to fuel or sources of generating fire and electricity. It seemed that they considered fuel or fire as symbols of energy. They usually explained that cards of fish, a boy running, a gas station, and dam did not relate to energy. They thought that those cards related to energy only when it could generate fire or source of generating fire and electricity. Moddaeng (Grade 5) clearly stated that the fish related to energy when people use fire to cook.

Interviewer: What is about this card?
Moddaeng: Fish. It does not relate to energy. But, it relates to energy when people fry it.

Obviously, students could explain their ideas about energy, but their explanations indicated that they had different alternative frameworks. Students' existing ideas about energy could be summarized as indicated in Table 1.

Table 1
Grade 1 to 6 Students' Ideas about Energy

Framework	Students' responses					
	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6
Electric energy	7	13	10	11	17	12
Potential energy	1	6	9	14	9	9
Mechanical energy and forces	7	4	9	6	4	4
Heat energy	0	0	0	1	0	3
Fuel	0	1	4	1	2	4

The results in Table indicate that the majority of students' responses from Grade 1 to 6 used the concept of electric energy to provide explanations about energy. Many Grade 1 - 3 students explained energy by referring to mechanical energy and forces and electric energy. Grade 4 – 6 students clarified their ideas about energy by referring to potential and electric energy. Upper primary school students referred to various forms of energy when they attempted to provide explanations about the cards presented to them. Additionally, it seemed that upper primary students were more inclined to refer to gravitational and chemical potential energy than lower primary students. Some upper primary school students mentioned that the dam, fuel, a dish of fish, and coal related to energy. Their explanations were mostly related to how a dam, fuel, a dish of fish, and coal "contained" energy after realizing that energy was transformed into other forms of energy. This indicated that upper primary students held the concept of energy transformations that helped them to mention more forms of energy. Although their explanations mentioned the concept of energy transformations, they did not mention how these cards related to a specific form of energy, but this was inferred indirectly. Thus, their explanations of energy transformations relating to the dam indicated that they considered the concept of gravitational potential energy, while their reference to fuel, coal, and a dish of fish clearly indicated that they implicitly exhibited the concept of chemical potential energy.

Grade 1 to 6 could not distinguish between forms and sources of energy. Although students usually considered the concept of energy transformations when they explained how the pictures in a card related to energy, they did not refer to several forms of energy, and they could not recognize energy degradation and the law of energy conservation. If they had a basic concept of the law of energy conservation, they might be able to suggest or consider energy degradation when referring to energy transformations. In fact, the law of energy conservation and energy degradation do not appear in Thailand primary school science curriculum.

Conclusions and Suggestions

Grade 1 to grade 6 students' explanations indicated that they held the concept of energy forms and that they indirectly recognized various forms of energy (e.g., electric, potential, mechanical, and heat energy). Their explanations could also be categorized into five frameworks. Regarding constructivist perspective, teachers need to know students' prior knowledge in order to take into consideration these viewpoints for designing and implementing teaching interventions (Trumper,

1990; Duit & Haeussler, 1994). Additionally, students' explanations indicated that they understood the concept of energy transformation, and that primary school teachers in Thailand could provide students with learning activities based on energy transformations. In other words, this group of primary school students could be easily taught the concept of forms of energy, energy transformations, transfer of energy, energy degradation, and the law of energy conservation.

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